Dec. 18, 1928. 1,696,157

E. S. FLARSHEIM

SPARK GAP

Filed Jan. 18, 1927

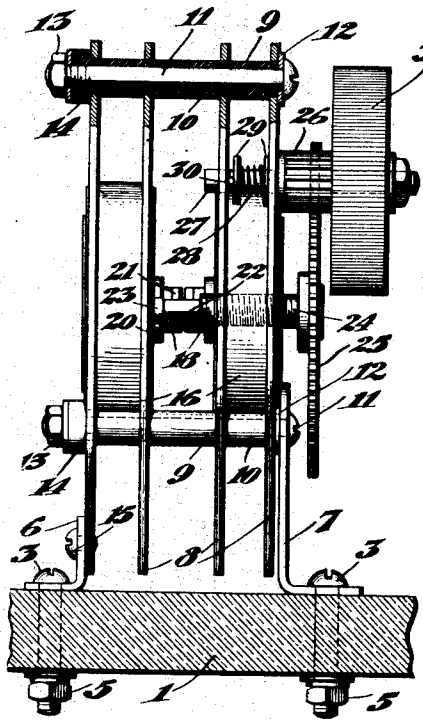


Fig. 2

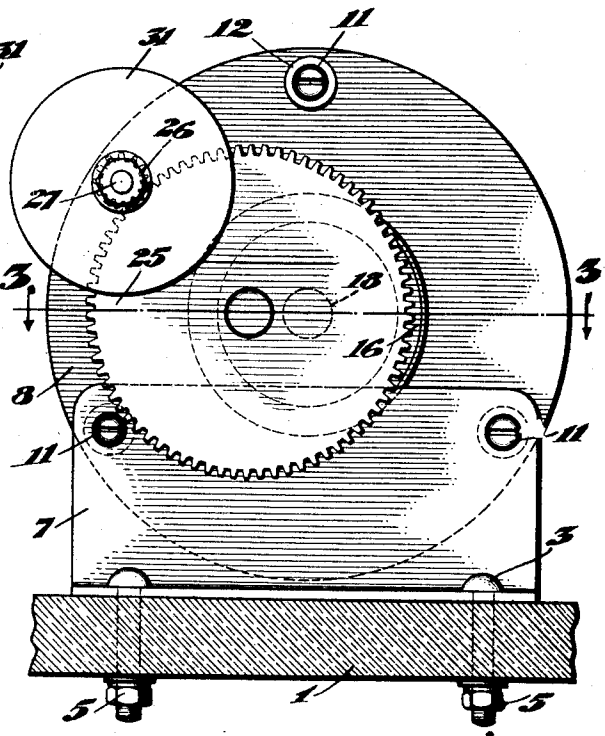


Fig. 1

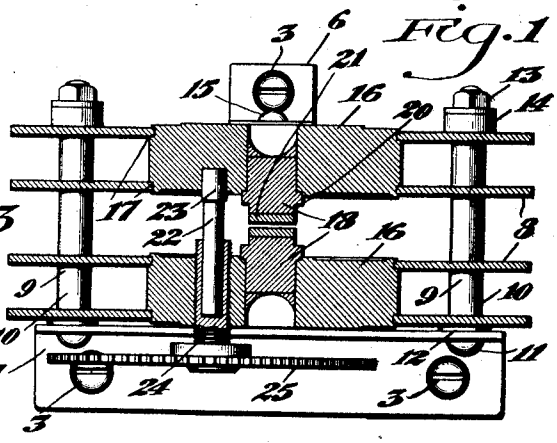
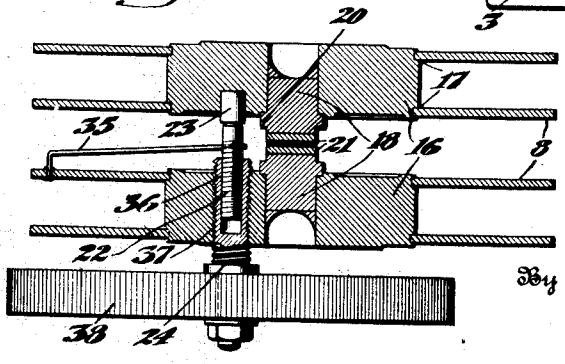


Fig. 3

Fig. 4



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Patented Dec. 18, 1928. 1,696,157

# UNITED STATES PATENT OFFICE.

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## SPARK GAP.

Application filed January 18, 1927. Serial No. 161,931.

My invention relates to spark gaps, and particularly to spark gaps adapted to produce high frequency oscillating currents in charged condenser circuits. Other factors being equal, the power in charged condenser circuits varies with and is controlled by the spacing of the electrodes of the spark gap. The spark gap of this invention is particularly intended for use in electrical high frequency current work, where the power, and the damping must be as definitely controllable as possible. The gap disclosed is specifically designed for use in an electrical cutting machine adapted to be utilized as the cutting instrumentality in surgical operations.

A machine of this nature employs a high tension electrical spark emanating from a comparatively dull edge as a flesh, tissue, fat or cartilage cutting medium. The cutting power of the spark is dependent on two factors, the voltage and amperage (or power), and the nature of the current, i. e. the damping. The tissue dehydrating power of the spark is also dependent on these same two factors. The greater the damping the greater is the dehydrating power and the less the cutting power. Both the dehydrating and the cutting effects vary directly with the amount of power used. In performing surgical operations it is necessary to maintain these factors constant at any desired point over a time sufficient in extent to perform the operation. Any variation in these factors during the operation not only would be highly annoying, but might cause failure in securing the desired results.

While spark gaps have been used to produce high frequency oscillating currents in charged condenser circuits, they have not been used in electrical cutting machines of this nature for the reason that heat is generated as the spark leaps between the electrodes, and the electrodes consequently expand thereby lessening the gap. This affects the power of the current and the damping of the oscillations and renders the conventional gap wholly unfit for the above mentioned purposes. Hence my invention is of primary importance in that it makes possible and safe the employment of a spark gap as both a functional and control instrumentality in this character of electrosurgical apparatuses.

Obviously, my invention is also of value in radio transmitters and all places where a spark gap is otherwise used.

One object of the invention is to provide a spark gap in which the spacing of the electrodes will remain constant despite the heat generated by the electric discharge.

Another object of my invention is to provide an organization of elements including two electrodes and a compensating electrode spacing member, the latter adapted to be affected by the heat generated by the spark, and expand in order to keep the length of the spark gap constant over a wide temperature range.

It is also obviously necessary to adjust the spacing of the electrodes very accurately in all work of the nature described, where the power, and the damping of the electrical oscillations must be accurately controlled.

Therefore, another object of my invention is to provide in combination with the compensating mechanism above mentioned, minute adjusting mechanism by which the operator is enabled to determine and fix the distance between the electrodes with great exactness and accuracy.

Other objects and certain advantages will be more fully set forth in the description of the accompanying drawings, forming a part of this specification, in which:

Figure 1 is a side view of the spark gap.

Figure 2 is an end view of the spark gap.

Figure 3 is a sectional view taken on line 3—3, Figure 1, showing the relation of the electrodes and the mechanism for adjusting the electrodes and the expansion members as a part of the adjustment mechanism.

Figure 4 is a view taken the same as Figure 3 but showing a modified form of adjustment means.

The spark gap of this invention comprises two electrodes, and a combined spacing and compensating element adjustable in length to determine the length of the gap between the two electrodes, and possessed of a coefficient of expansion selected with reference to the coefficient of expansion of the electrodes, to maintain the electrodes the same distance apart as the spark generates heat, and both the electrodes and the spacer consequently expand.

The spacer can be adjusted either by means of a screw rotated through reduced

motion gearing, or the spacer can be adjusted by means of two screws of different pitch, the simultaneous rotation of which produces reduced motion according to the pitch differential. The preferred gap organization comprises compression means which tends to close the gap and compensating spacing means controlled through reduced motion mechanism operating against said compression means to open the gap.

More specifically, a base 1 has secured thereto by means of screws 3, and nuts 5, two angular brackets, one a narrow bracket 6, the other a wider bracket 7. The spark gap is mounted on these brackets, the adjustment mechanism being supported over the wider bracket. Compression means are provided which tend to press the electrodes together. Said means comprises two sets of flexible plates or disks 8, two to a set. These disks have the additional function of radiating the heat from the electrodes. One electrode is carried centrally by each set of flexible disks. These disks are held together by means of three insulating assembling posts 9, each assembling post extending loosely through all four disks. Thus each set of disks carrying its electrode is insulated from the opposing set. Wires (not shown) are connected in any desirable way to the opposing sets and the gap thus incorporated in the electric circuit.

Each assembling post consists of a hollow insulating cylinder 10 which extends through the disks 8, a screw 11 which passes through the hollow cylinder, a washer 12 between the screw head and an outer disk, and a nut 13 on the other end of the screw with an insulating washer 14 between the nut and the other outer disk.

As disclosed, there are three of these assembling posts, the lower two of which are used to secure the disks to the wide bracket 7. The narrow bracket 6 is secured to the other outer disk by means of a screw 15. The disks are thus concentrically mounted and secured together by these assembling posts. This construction constitutes the outer disks, the main compression elements, and the inner disk guide elements to keep the electrodes in proper alignment. All the disks have at their centers equal sized circular apertures. Each pair of disks has an electrode holder 16 mounted in these apertures between the disks. As disclosed, these electrode holders are circular and each has cut at each edge a circumferential shoulder or notch 17 into which the disks fit. These electrode holders have also concentric hollow centers and in these centers are the electrodes 18 preferably being pressed into said centers and held also by solder. These electrodes have flanges 20 which seat in depressions in the electrode holder faces. These electrodes are preferably of copper or other metal of good thermal conductivity, and are provided with faces 21 of tungsten. The electrodes project beyond the holders to an extent that the opposing surfaces 21 may contact each other.

The means for securing adjustable spacing between these electrodes comprises a spacing element 22 carried by one electrode holder which is adapted to bear against a porcelain anvil 23 carried by the opposing electrode holder thereby forcing the electrode holders and electrodes apart. This spacing element is adjusted in relation to its carrying electrode holder by means of a recessed screw 24 in which it is loosely mounted and which in turn screws in and out of the electrode holder. In order to provide a delicate adjusting mechanism, the screw is provided at its outer end with a large and narrow gear wheel 25 which intermeshes with a small but wide pinion 26 mounted on a shaft 27 which is passing through and is supported by the set of disks which carry the corresponding electrode holder. About this shaft 27 between the two disks, is a coiled spring 28 under compression between two washers 29. A pin 30 secures the shaft 27 against longitudinal displacement. This journaling provides friction so that the pinion cannot be too easily turned or accidentally turned. On the outer end of this pinion shaft is an adjustment knob 31 secured to the shaft.

The modification of the adjusting mechanism shown in Figure 4 comprises a rod 35 which holds the spacing member against rotation. Instead of being imbedded in the adjustment screw, this spacing member screws into the adjustment screw, the thread 36 being opposite to but different in pitch from the thread 37 between the adjustment screw and the electrode carrier. The adjustment screw has on its outer end a conventional turning knob 38 secured thereto by means of a nut and washer. In operation, turning this knob effects a very slight differential motion between the two screws, thereby permitting and effecting very delicate and exact adjustment of the electrodes with relation to each other.

In either case, as the electrodes become heated and expand, thereby tending to lessen the length of the spark gap between them, the spacing member also expands forcing the electrode carriers farther apart thereby compensating for said electrode expansion. The coefficient of expansion of the material used, must be very carefully selected in order to secure this relative permanence of setting. The farther the spacing member is from the electrodes and the heat generated thereby, the higher must be its coefficient of expansion in order that it may function properly as a compensating member.

Thus, I provide a spark gap adapted to be adjusted through reduced motion mechanism, and set with extreme accuracy, the gap also provided with a compensating electrode spacer adapted to maintain the length of the gap constant over a wide temperature range.

Having described my invention, I claim:

1. A spark gap comprising two electrodes, and an adjustable spacing member determining and controlling the gap between said electrodes, said spacing member exposed to the heat generated by the spark and adapted to expand and compensate for the electrode expansion thereby maintaining the gap relatively fixed over a wide temperature range.

2. A spark gap comprising two opposing electrodes, a tension element pressing said electrodes together, and a spacing member holding said electrodes apart, said spacing member having a coefficient of expansion adapted to compensate for the expansion of the electrodes when heated in order to maintain a constant gap between the electrodes.

3. A spark gap comprising two opposing electrodes, a spacing member controlling the gap between the electrodes, said spacing member possessed of a coefficient of expansion adapted to compensate for electrode expansion and maintain the gap constant over a wide temperature range, a knob for adjusting said spacing member, and reduced motion mechanism connecting said knob and spacing member in order to provide for the delicate adjustment of the latter.

4. A spark gap comprising two electrodes, compression means tending to close the gap, and compensating spacing means controlled through reduced motion mechanism operating against said compression means to open the gap.

5. A spark gap comprising a base having mounted thereon two opposing flexible disks, two opposing electrodes each carried by a disk and projecting therefrom to a contacting extent, compensating spacing means between said disks, said spacing means adapted to space the electrodes against the tension of the disks, and means for imparting minute motion to said compensating electrode spacing means to determine the gap between said electrodes.

6. A spark gap comprising a base having mounted thereon two opposing flexible disks, two opposing electrodes each carried by a disk, and projecting therefrom to a contacting extent, a screw carried by one disk, an electrode spacer secured to said screw said spacer adapted to space the electrodes against the tension of the disks as the screw is turned inwardly, a large gear wheel on the outer end of said screw, a small pinion in mesh with said large gear wheel, a shaft adapted to turn said small pinion, a friction-producing member associated with said shaft to prevent said shaft from being too easily turned, and a knob on the outer end of said shaft adapted to turn the same and transmit motion to the electrode spacer through said specified reduced motion mechanism.

7. A spark gap comprising a base having mounted thereon two sets of opposing flexible disks of two each, said disks concentrically mounted with respect to one another, insulating assembling posts passing through all of said disks to maintain them in said concentric relationship, two concentric electrode carriers each mounted centrally between the two disks of each opposing set, two opposing electrodes each centrally secured in an electrode carrier and projecting therefrom to a contacting extent, an anvil carried by one electrode carrier, a screw carried by the other electrode carrier, said screw opposite to said anvil, a compensating electrode spacer carried by said screw, said spacer adapted to contact said anvil and act against the tension of the disks to space the electrodes as the screw is turned inwardly, and means for imparting minute motion to said compensating electrode spacer.

8. A spark gap comprising a base having mounted thereon two sets of opposing flexible disks, said disks concentrically mounted with respect to one another, insulating assembling posts passing through all of said disks to maintain them in said concentric relationship, two concentric electrode carriers one mounted centrally in each opposing set of disks, two opposing electrodes each centrally secured in an electrode carrier and projecting therefrom to a contacting extent, an anvil carried by one electrode carrier, a screw carried by the other electrode carrier, said screw opposite to said anvil, a compensating electrode spacer carried by said screw, said spacer adapted to contact said anvil and act against the tension of the disks to space the electrodes as the screw is turned inwardly, a large gear wheel on the outer end of said screw, a small pinion in mesh with said large gear wheel, a shaft adapted to turn said small pinion, and means adapted to turn the shaft and transmit motion to the electrode spacer through said specified reduced motion mechanism.

9. A spark gap comprising a base having mounted thereon two sets of opposing flexible disks of two each, said disks concentrically mounted with respect to one another, three insulating assembling posts passing through all of said disks to maintain them in said concentric relationship, two concentric electrode carriers each mounted centrally between the two disks of each opposing set, two opposing electrodes each centrally secured in an electrode car-

rier and projecting therefrom to a contacting extent, an anvil carried by one electrode carrier, a screw carried by the other electrode carrier, said screw opposite to said anvil, a compensating electrode spacer carried by said screw, said spacer adapted to contact said anvil and act against the tension of the disks to space the electrodes as the screw is turned inwardly, a large gear wheel on the outer end of said screw, a small pinion in mesh with said large gear wheel, a shaft adapted to turn said small pinion, a friction producing member associated with said shaft to prevent said shaft from being too easily turned, and a knob on the outer end of said shaft adapted to turn the same and transmit motion to the electrode spacer through said specified reduced motion mechanism.

In witness whereof, I hereunto subscribe my name.

EDWIN S. FLARSHEIM.